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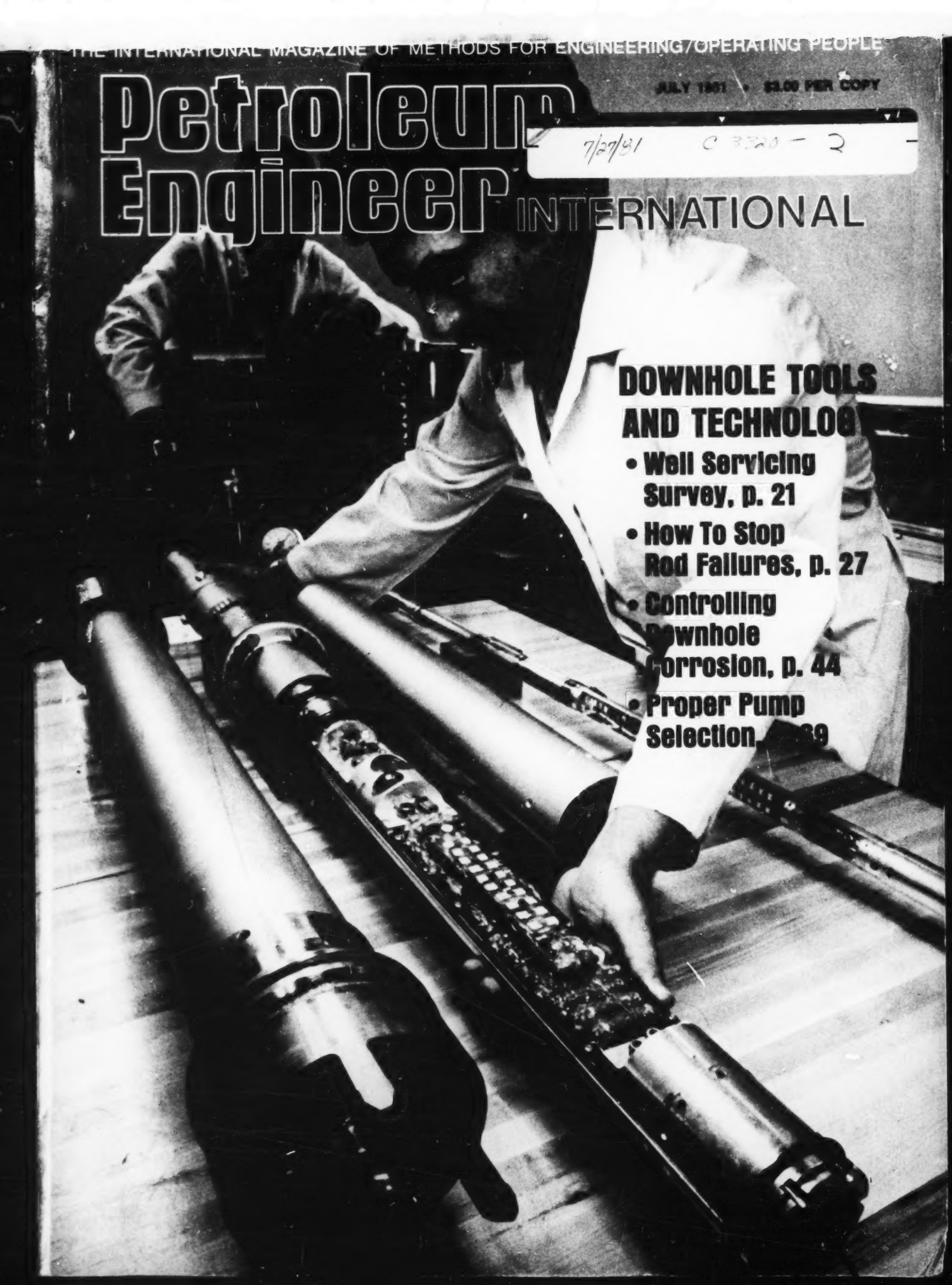

DOWNHOLE TOOLS AND TECHNOLOGY

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Springtime Slump Prolonged In Canada

U.S. drillers are still setting records each week, while their Canadian counterparts are showing signs of coming only part of the way back from the annual springtime slump which reached its low point this year on May 4 when only 147 rigs were reported to be turning north of the border. A month later, the Canadian count was almost 100 rigs higher, but it still was almost 200 rigs short of where it was at the same time last year. Canadian drillers in 1980 practically ignored the spring thaw altogether in compiling their best record ever. This year, the slump has taken its toll.

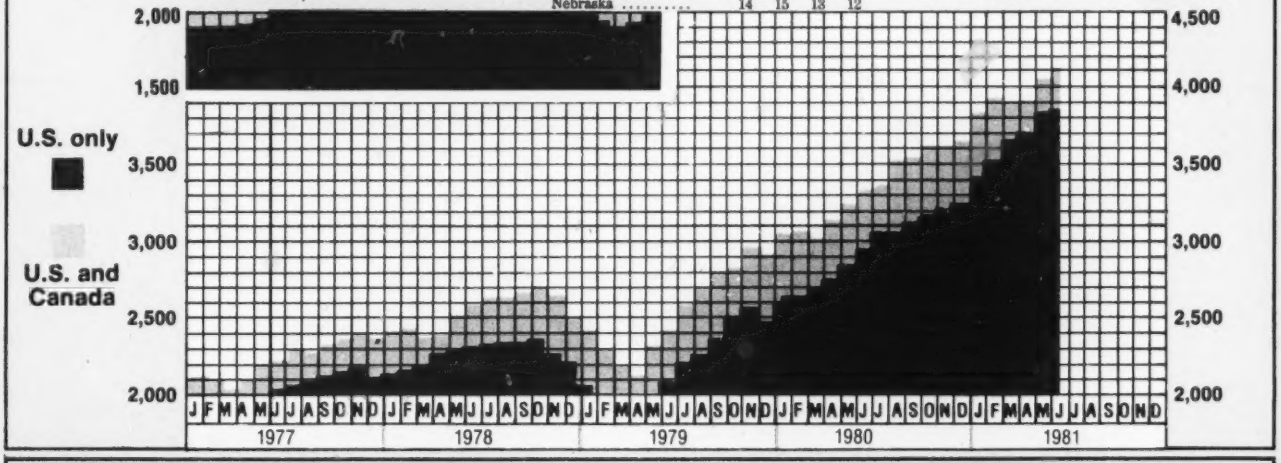
The average weekly rig count in Canada this year stood at 420 on March 9. Just 13 weeks later, on June 8, the weekly average had dropped to 304.

What the situation on both sides of the border adds up to is a classic example of the effects of governmental activities.

Rotary Rigs Actually Making Hole In United States & Canada

As Reported to International Association of Drilling Contractors by Hughes Tool Co.

	May 18, 1981	May 26, 1981	June 1, 1981	June 8, 1981
Alabama				
Offshore	3	3	3	3
Land	17	18	10	12
Alaska				
Land	22	20	21	22
Offshore	2	2	4	4
Total	24	22	25	26
Arkansas	32	33	33	34
Arizona	1	2	2	2
California				
Land	132	130	132	130
Offshore	20	20	20	20
Total	152	150	152	150
Colorado	68	72	73	79
Florida				
Land	6	6	6	6
Offshore	3	3	3	3
Total	9	9	9	9
Georgia	1	1	1	1
Hawaii	1	1	1	1
Idaho	3	3	3	3
Illinois	27	27	28	25
Kansas	198	192	191	193
Kentucky	0	1	1	0
North Louisiana	54	57	61	62
South Louisiana				
Inland Waters	84	81	75	83
Land	152	143	143	150
Offshore	145	142	138	146
Total	435	423	417	441
Maryland	1	1	1	1
Michigan	40	40	51	42
Mississippi	71	64	69	72
Montana	80	70	72	74
Nebraska	14	15	13	12
Nevada	7	6	6	6
New Mexico	135	130	135	126
New York	7	7	8	11
North Dakota	118	125	126	119
Ohio	99	103	105	111
Oklahoma	648	655	669	664
Oregon	1	1	2	2
Pennsylvania	35	35	34	32
Rhode Island	1	1	1	1
South Dakota	2	2	2	2
Texas				
Offshore	71	71	68	72
Dist. 1	74	77	73	72
Dist. 2	76	74	79	69
Dist. 3	246	247	241	229
Dist. 4	117	119	116	116
Dist. 5 & 6	157	163	162	169
Dist. 7B	92	90	86	91
Dist. 7C	97	93	91	86
Dist. 8	150	162	164	157
Dist. 8A	85	82	86	84
Dist. 9	81	84	85	87
Dist. 10	63	68	67	63
Total	1309	1330	1318	1295
Utah	76	68	69	77
Virgina	2	3	3	3
Washington	1	1	1	1
West Virginia	38	42	40	41
Wyoming	182	186	184	189
Total U.S.	3828	3842	3858	3860
Western Canada	161	200	218	237
Eastern Canada	3	3	3	4
U.S. and Canada	3992	4045	4079	4101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ABOUT THE COVER: Technician checks out downhole instrument package for measurement-while-drilling system designed to save rig time and improve drilling accuracy. (Photo courtesy of Eastman Whipstock.)

NEXT MONTH: New methods and technology being applied to maximize recovery of oil and gas will be the subject of the Production Technology Report in August.

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International Report

The International Energy Agency and the Organization for Economic Cooperation and Development report that crude oil production in the OECD area increased 1.1% in 1980 to 702.2 million tons (about 5.1 billion bbl). Consumption was down 7%.

OECD net oil imports dropped 12.6% during 1980 to 1,143.7 million tons (about 8.3 billion bbl). Norway and the UK increased their production in 1980 by 28 and 3.3%, respectively.

Stocks of crude oil and products in the OECD area at the end of last year totaled 462.8 million tons (3.3 billion bbl), compared with 443.9 million tons (3.2 billion bbl) at the end of 1979.

In what is believed to be the first exploration and development agreement between China and a U.S. oil company, Arco International Oil & Gas Co. and Santa Fe International Corp. plan to develop a 3,500-sq-mile section of the Ying Ge Hai Basin in the South China Sea. The companies have conducted seismic tests of the region, and exploratory drilling is scheduled to begin later this year.

Terms of the production-sharing agreement reportedly are similar to Indonesian contracts in which the country takes 85% of production.

Currently there are only two other exploration arrangements between the Chinese and foreign companies. One is with the French company Total for exploration of the Gulf of Tonkin and the South China Sea, and the other is with a Japanese group for exploration of Pohai Bay.

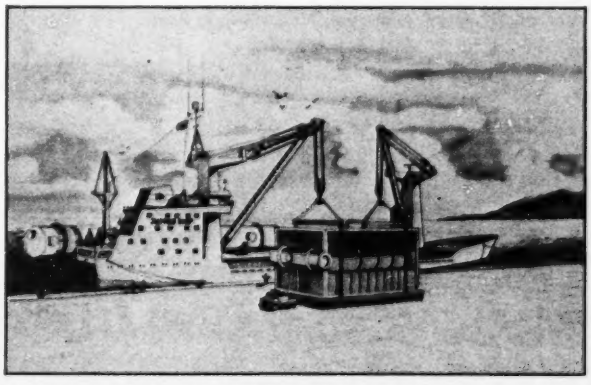
Drilling in Pohai Bay already has turned up an oil find, in Japan National Oil's No. 1 well. The oil reportedly is light, low in wax content, and ideal for Japanese refineries that are designed to process Arabian light grades, not the heavy, waxy oil supplied to Japan from such Chinese onshore fields as Daqing.

Japan National Oil Corp. is scheduled to drill five wells in Pohai Bay this year, and some unofficial Japanese estimates put reserves there as high as 75 billion bbl. Others believe, however, that Pohai Bay's oil is scattered in rich but small pockets, and that earthquakes in the region have disrupted oil-bearing strata, making the oil hard to tap.

Two super-heavy-lift module carriers are under construction by the Dutch shipbuilding company Ysselvliet Combinatie. The fourth generation of Jumbo heavy-lift carriers, the two vessels will be much bigger and heavier than those of preceding generations.

Being built for Khan Heavy Lift BV and Fairplay Scheepvaart BV, the ships will be able to load and discharge pieces up to 1,000 tons. To achieve this, each ship will be equipped with two derricks capable of lifting 500 tons apiece. The derricks are to be unconventionally positioned, with the aft derrick entirely on the starboard and the forward derrick entirely on portside. This allows for an extra-long hatch and substantial free deckspace, thereby permitting transport of pieces longer than 300 ft and wider than 60 ft.

The first of the new ships is to be delivered by the end of 1982, and the second by the middle of 1983.



A feature of the new ships will be a superstructure that occupies only a small space aft, on starboard only, creating a level and clear deck, much like an aircraft carrier.

A survey by Norway's Ministry of Petroleum and Energy indicates that the proven recoverable reserves of gas on the Norwegian continental shelf south of the 62nd parallel amount to almost 46 trillion cubic feet (tcf). The value of the gas is normally put at $6.35/Mcf, which means that the value of the reserves proven so far is approximately (U.S.) $300 billion.

Proven gas fields on the Norwegian shelf south of the 62nd parallel.

Field	Gas reserves billion cu ft
Ekofisk	3,920
Albuskjel	812
Cod	282
Edda	212
Eldfisk	1,836
Tor	635
Frigg	4,485
Northeast Frigg	494
Odin	777
Statfjord	1,412
Valhall	989
West Ekofisk	989
Heimdal	1,271
Hod	318
Sleipner	5,120
Valhall B	847
Block 1/9-A	388
Block 1/9-G	459
Block 15/3	2,225
Block 25/2	424
Block 30/6 (the silver block)	2,119
Block 30/7	882
Block 31/2 (estimated)	14,125
Block 31/6	28,251
Block 34/10 (gold block-D)	247
Block 34/10 (gold block-A)	141
Total	**73,660**

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Total value of gas reserves on Norwegian shelf, however, may be in the region of $701 billion. The Ministry of Petroleum and Energy has, in fact, calculated that the gas reserves in one area alone (sector 31, west of Bergen) may be between 64 and 67 tcf.

The Petroleum Directorate in Stavanger operates with figures for probable oil and gas reserves south of the 62nd parallel of approximately 34 billion bbl of oil equivalent. Gas probably constitutes about 54% of this, which means that there are about 85 tcf of gas in the area south of the island of Stad (outside Bergen) alone. This constitutes about 15% of the Norwegian continental shelf.

If the Norwegian Storting (Parliament) goes along with the government's plans to pipe gas ashore from Statfjord, Heimdal, and the gold block (34/10), therefore, Norway will, towards the late 1980s, emerge as a nation that is not only rich in oil, but in gas as well.

The Norwegian Information Council reports that the government wants to pipe Norwegian gas ashore at Karsto, north of Stavanger. Up to now, wet gas has been used as a petrochemical feedstock in Norway and dry gas has been exported to the Continent through the pipeline from Ekofisk to Emden in West Germany.

Another possibility is that gas will be found offshore northern Norway, which could lead to establishment of a petrochemical industry in that area. The state oil company, Statoil, already has begun a $27 million research project into this possibility. Although there is no market at present for large quantities of gas off northern Norway, it is generally agreed that a market will emerge in the not-too-distant future.

Hakon Lavik, Statoil's press spokesman, says that if the company does discover large amounts of gas off northern Norway, "it will most probably be brought to land for separation and further processing. The pros and cons of utilizing the dry and wet gas in north Norway will differ from those applying to the North Sea gas."

Lavik says that Statoil is building up a "knowledge bank" for exploitation of Norwegian Sea gas, and he added that Mobil Oil Corp. is taking part in a research project leading to conversion of methanol into synthetic gasoline. This, Lavik feels, could lead to interesting possibilities for potential gas finds farther north. Statoil, however, is interested in more than synthetic gasoline. The company also is studying the possibilities of exporting dry gas to Sweden and Finland, which have already expressed interest in small quantities of the gas for industrial use.

The accompanying table lists proven gas fields that are in production, under development, or capable of being developed. If recent estimates that the entire 31 area contains between 64 and 67 tcf of natural gas are correct, another 21 to 24 tcf can be added to the total of 73.6 tcf.

Norway's probable gas reserves then would exceed 90 tcf. This corresponds to about 18 trillion bbl of oil for Norway, where the current annual comsumption is approximately 67 million bbl.

Well Servicing Boom Pushes Costs Over $3 Billion

by Steven D. Moore, *Technical Editor*

TABLE 1. Completion, workover, servicing summary, by region, 1980

Region	Total wells	Completion, recompletion	Total art. lift	Lift repair	New lift installation	Tubular repair	Frac/acid stimulate	Total budget, $M
U.S.[1]	734,728	71,069	500,396	464,566	25,631	56,164	20,119	3,201,074
Appalachia	122,141	7,039	62,146	50,468	1,364	5,709	147	240,460
California onshore	45,847	2,686	42,472	40,419	1,439	3,587	920	159,010
California offshore	1,564	148	1,952	100	13	81	32	32,694
Four Corners	12,730	954	1,434	1,898	1,334	161	56	36,859
Great Lakes	75,543	7,605	53,775	45,560	2,406	5,266	550	149,910
Gulf of Mexico	8,899	735	3,567	721	293	238	171	180,780
Louisiana onshore	33,915	5,275	20,930	20,606	1,512	1,640	1,630	194,840
Mid-Continent	170,286	17,022	131,520	119,592	6,629	15,089	5,968	656,230
Rocky-Williston	28,553	4,400	19,109	20,922	1,494	2,013	3,356	402,340
Texas onshore[2]	231,052	24,713	160,107	161,372	8,962	21,943	7,067	1,118,400
Southeast	4,198	492	3,384	2,908	185	437	222	29,551

(1) Excludes 571 wells in Alaska
(2) Includes southeast New Mexico

For the second year in a row, producers will spend more than $3 billion to work over U.S. oil and gas wells. By year's end, 1981 well servicing expenditures should exceed those of 1980.

Well servicing operators performed nearly 568,000 servicing and repair jobs on 734,728 operating wells in the U.S. during 1980. In addition, 71,000 wells were completed or recompleted last year. The total well servicing budget for 1980 surpassed $3.2 billion.

Well servicing, like the more-publicized contract drilling boom, is rapidly expanding. Inflation helped push the total projected 1981 well servicing budget towards $3.6 billion but the real cause is increased activity, due largely to oil decontrol and rising world oil prices during the last few years. In fact, if PETROLEUM ENGINEER INTERNATIONAL's annual well servicing survey were taken today, after producers felt the effects of President Reagan's decontrol measure, estimated well servicing expenditures would be even higher.

The most significant change in well servicing trends was reduced abandonments–the number of abandoned wells dropped from 9,011 in 1979 to 3,021 in 1980.

This year, PEI divided the survey into 11 different geographic regions–for the first time, the Appalachia area is broken out. Tables 1, 2, and 4 summarize completion, workover, and servicing activities in 1980. Tables 5 through 15 depict servicing operations for individual regions.

Big Budget

Budgets for well servicing costs per well vary from region to region. The largest regional budget for 1980 was in Texas–where it exceeded $1 billion. Last year, Texas wells required 199,344 servicing jobs, plus 24,415 completions and recompletions.

Another area high on the list is the Mid-Continent, where Oklahoma and Kansas are experiencing extensive growth. The area probably has the widest variance in well servicing costs per well because of relatively low maintenance costs for shallow wells, particularly in Kansas, as opposed to high-priced stimulation jobs for many of Oklahoma's deeper wells.

The Gulf of Mexico is again the most expensive region for workover costs per well. Daily rates for workover barges and jackups, along with high transportation charges, cause expenses to climb.

Least expensive of the 11 regions are the Great

TABLE 2. Completions and recompletions of exploration and development wells, by region

	Wells Jan. 1, 1981		Exploration		Development		Recompletions		
	Oil	Gas	Oil	Gas	Oil	Gas	Same zone	New zone	Abandons
U.S.	553,369	181,359	1,595	1,969	25,306	15,506	15,846	10,847	3,021
Appalachia	63,431	58,710	131	334	1,579	4,204	716	75	110
California onshore	44,932	915	88	45	1,667	32	506	348	142
California offshore	1,564	—	2	—	65	—	65	16	5
Four Corners	1,641	11,089	9	25	126	670	74	50	24
Great Lakes	56,136	19,407	225	88	2,792	2,122	887	1,491	47
Gulf of Mexico	5,298	3,601	1	10	130	240	118	236	29
Louisiana onshore	23,296	10,619	32	57	1,146	1,515	1,818	707	334
Mid-Continent	141,236	29,050	288	208	7,072	2,758	4,706	1,990	860
Rocky-Williston	22,383	6,170	236	204	1,345	1,013	613	989	180
Texas onshore	190,071	40,981	556	976	9,215	2,855	6,266	4,845	1,198
Southeast	3,381	817	27	22	169	97	77	100	92

TABLE 3. Tubular goods repair, by region

	Casing			Tubing		
	1978	1979	1980	1978	1979	1980
U.S.	6,631	3,772	6,566	24,615	62,946	49,598
Appalachia	—	—	926	—	—	4,783
California onshore	1,424	71	302	1,505	1,256	3,285
California offshore	—	—	14	—	60	67
Four Corners	—	85	32	—	505	129
Great Lakes	—	300	609	—	4,500	4,657
Gulf of Mexico	23	—	30	24	182	208
Louisiana onshore	211	180	189	1,631	1,513	1,451
Mid-Continent	1,381	1,400	1,944	11,055	25,202	13,145
Rocky-Williston	297	431	377	471	1,255	1,636
Texas onshore	3,295	1,263	2,097	9,929	28,116	19,846
Southeast	—	42	46	—	357	391

Lakes and Appalachia. The low cost per well is due to the shallow depth of most producers and the rod pumping units used–in most cases, the cheapest artificial lift to operate and maintain. However, in the future, these two areas will take an increasing chunk of the total U.S. well servicing budget, as Ohio, Pennsylvania, West Virginia, and Illinois all ranked in the 10 top states for completions in 1980.

Completions Rising

Despite the windfall profits tax placed on decontrolled crude, total well completions rocketed in 1980. It's no great surprise to see 1981's pace even more hectic.

Oil well completions showed the biggest increase – from 19,383 completions in 1979 to 27,026 in 1980. The drilling surge also affected recompletions; operators recompleted some 26,000 wells. Table 2 gives a breakdown of completions and recompletions. Areas having the greatest activity are Texas, the Mid-Continent, and California, where many old, marginal fields are being reevaluated.

For the sixth straight year, producing oil wells increased. In 1980, the number of oil wells reached 553,369–a 5% jump over 1979–with more than 500,000 oil wells on artificial lift. Last year operators brought many abandoned stripper wells back on production. While the total barrels of oil for stripper production increased last year, the average daily production rate for a U.S. oil well sank to under 16 b/d.

Tubular Demand

Worries over supply shortages for new completions lessen as tubular manufacturers increase production and suppliers raise imports. An adequate supply is vital to the well servicing market as tubing replacements should be on a record clip this year. Responses to PEI's survey show a decrease in the number of tubing repairs

TABLE 4. Total U.S. service jobs in 1980

Abandoned (old wells)	3,021
Recompletions–same reservoir	15,846
Recompletions–different reservoir	10,847
Stimulation–acid or frac	20,119
Tubing repair or replacement	49,598
Casing repair	6,566
Rod pump repair	243,020
Sucker rod work	199,507
New rod pump installation	22,467
Submersible pump repair	8,947
New submersible pump installation	1,420
Hydraulic pump repair	9,795
New hydraulic pump installation	781
Gas lift repair	3,297
New gas lift installation	963

TABLE 5. Appalachia service jobs in 1980

Abandoned (old wells)	110
Recompletions–same reservoir	716
Recompletions–different reservoir	75
Stimulation–acid or frac	147
Tubing repair or replacement	4,783
Casing repair	926
Rod pump repair	28,207
Sucker rod work	22,261
New rod pump installation	1,364
Submersible pump repair	—
New submersible pump installation	—
Hydraulic pump repair	—
New hydraulic pump installation	—
Gas lift repair	—
New gas lift installation	—

TABLE 6. California onshore service jobs in 1980

Abandoned (old wells)	142
Recompletions–same reservoir	506
Recompletions–different reservoir	348
Stimulation–acid or frac	920
Tubing repair or replacement	3,285
Casing repair	302
Rod pump repair	19,980
Sucker rod work	16,486
New rod pump installation	1,399
Submersible pump repair	149
New submersible pump installation	9
Hydraulic pump repair	3,605
New hydraulic pump installation	15
Gas lift repair	199
New gas lift installation	16

TABLE 7. California offshore service jobs in 1980

Abandoned (old wells)	5
Recompletions–same reservoir	65
Recompletions–different reservoir	16
Stimulation–acid or frac	32
Tubing repair or replacement	67
Casing repair	14
Rod pump repair	—
Sucker rod work	—
New rod pump installation	—
Submersible pump repair	83
New submersible pump installation	5
Hydraulic pump repair	—
New hydraulic pump installation	—
Gas lift repair	17
New gas lift installation	8

and replacements from 1979 to 1980, while the number of casing repair jobs increased (Table 3). Texas led once again in tubing and casing repairs and replacements, followed by the Mid-Continent.

Pumping Units

Oil wells brought on stream with rod pumping units increased from 9,473 wells in 1979 to 21,029 wells in 1980. Expect an even bigger boost this year as operators continue to tap new fields that were once considered marginal and step up infill drilling in many of the country's older fields. Rod pumping units still supply 85% of all artificial lifts for oil wells.

Last year, approximately 113 million ft of new sucker rods were delivered to the industry, with nearly 20 million ft used to replace old rods. Many operators use new sucker rods for rejuvenated stripper wells because old rods fail more frequently, creating larger well servicing costs. Operators prefer to pay the initial higher cost of new rods in exchange for reduced well servicing bills.

Because of the sucker rod demand increase, new manufacturers are entering the market – many who manufacture non-API rated rods for limited service. These rods have no shoulder joints, so they cost less, but they will not stand up as well as API rated rods under constant stress.

Of the 113 million ft of sucker rods delivered last year, most went to Texas and the Mid-Continent–some 79 million ft in all. Now manufacturers sell only one sucker rod string at a given time to a specified well site to eliminate stockpiling. However, all rod manufacturers are expanding facilities and should be producing additional rods by this fall. Several manufacturers feel that 1981 could be a peak year for the sucker rod business because of all the abandoned wells brought back on production.

Other Lifts

Gas lift also has an increasing marketplace. While new gas lift installations remained about the same as 1979–approximately 10% of the artificial lift market–gas lift repairs increased by 41% from 1,046 repair jobs in 1979 to 3,233 in 1980. These numbers might be slightly off, however, because several operators feel that "... the majority of gas lift valves are not installed in initial completions". Even though gas lift valves are installed for the first time in a producing well, the

TABLE 8. Four Corners service jobs in 1980

Abandoned (old wells)	24
Recompletions–same reservoir	74
Recompletions–different reservoir	50
Stimulation–acid or frac	56
Tubing repair or replacement	129
Casing repair	32
Rod pump repair	729
Sucker rod work	602
New rod pump installation	1,309
Submersible pump repair	567
New submersible pump installation	25
Hydraulic pump repair	—
New hydraulic pump installation	—
Gas lift repair	—
New gas lift installation	—

TABLE 9. Great Lakes (Michigan, Ohio, Indiana, Illinois) service jobs in 1980

Abandoned (old wells)	47
Recompletions–same reservoir	887
Recompletions–different reservoir	1,491
Stimulation–acid or frac	550
Tubing repair or replacement	4,657
Casing repair	609
Rod pump repair	24,963
Sucker rod work	20,597
New rod pump installation	2,406
Submersible pump repair	—
New submersible pump installation	—
Hydraulic pump repair	—
New hydraulic pump installation	—
Gas lift repair	—
New gas lift installation	—

TABLE 10. Gulf of Mexico service jobs in 1980

Abandoned (old wells)	29
Recompletions–same reservoir	118
Recompletions–different reservoir	236
Stimulation–acid or frac	171
Tubing repair or replacement	208
Casing repair	30
Rod pump repair	—
Sucker rod work	—
New rod pump installation	—
Submersible pump repair	16
New submersible pump installation	1
Hydraulic pump repair	40
New hydraulic pump installation	18
Gas lift repair	665
New gas lift installation	274

TABLE 11. Louisiana onshore service jobs in 1980

Abandoned (old wells)	334
Recompletions–same reservoir	1,818
Recompletions–different reservoir	707
Stimulation–acid or frac	1,630
Tubing repair or replacement	1,451
Casing repair	189
Rod pump repair	10,359
Sucker rod work	8,548
New rod pump installation	939
Submersible pump repair	111
New submersible pump installation	101
Hydraulic pump repair	796
New hydraulic pump installation	128
Gas lift repair	792
New gas lift installation	344

TABLE 12. Mid-Continent service jobs in 1980

Abandoned (old wells)	860
Recompletions–same reservoir	4,706
Recompletions–different reservoir	1,990
Stimulation–acid or frac	5,968
Tubing repair or replacement	13,145
Casing repair	1,944
Rod pump repair	62,805
Sucker rod work	51,821
New rod pump installation	5,870
Submersible pump repair	4,222
New submersible pump installation	690
Hydraulic pump repair	740
New hydraulic pump installation	69
Gas lift repair	4
New gas lift installation	—

TABLE 13. Rocky Mountain-Williston Basin service jobs in 1980

Abandoned (old wells)	180
Recompletions–same reservoir	613
Recompletions–different reservoir	989
Stimulation–acid or frac	3,356
Tubing repair or replacement	1,636
Casing repair	377
Rod pump repair	9,953
Sucker rod work	8,213
New rod pump installation	1,229
Submersible pump repair	567
New submersible pump installation	121
Hydraulic pump repair	2,097
New hydraulic pump installation	116
Gas lift repair	92
New gas lift installation	28

TABLE 14. Texas onshore service jobs in 1980

Abandoned (old wells)	1,198
Recompletions–same reservoir	6,266
Recompletions–different reservoir	4,845
Stimulation–acid or frac	7,067
Tubing repair or replacement	19,846
Casing repair	2,097
Rod pump repair	84,521
Sucker rod work	69,739
New rod pump installation	7,794
Submersible pump repair	3,146
New submersible pump installation	452
Hydraulic pump repair	2,438
New hydraulic pump installation	423
Gas lift repair	1,528
New gas lift installation	293

TABLE 15. Southeast service jobs in 1980

Abandoned (old wells)	92
Recompletions–same reservoir	77
Recompletions–different reservoir	100
Stimulation–acid or frac	222
Tubing repair or replacement	391
Casing repair	46
Rod pump repair	1,503
Sucker rod work	1,240
New rod pump installation	157
Submersible pump repair	86
New submersible pump installation	16
Hydraulic pump repair	79
New hydraulic pump installation	12
Gas lift repair	—
New gas lift installation	—

operator considers the installation as remedial work.

Electric submersible and hydraulic pumps maintain approximately the same percentage of the artificial market (2% each), but the number of wells using these types of lifts is increasing. Approximately 1,450 submersible units were installed in 1980, bringing the total number of electric submersible pumps operating in the U.S. to about 10,940.

In 1979, submersible pumps had an 0.97 failure rate–about 375 days without a breakdown. Service improved last year to an 0.86 failure rate, or a 425-day working life. Hydraulic pumps had approximately the same number of new installations in 1980 as electric submersibles, with about the same failure rate.

Stimulation

Acid and frac stimulation jobs for old wells rose from 19,319 in 1979 to 20,392 in 1980, but the actual number could be even higher. Stimulation jobs are becoming commonplace in many older fields, particularly in Texas and the Mid-Continent.

The Great Lakes and Appalachia area operators are performing more stimulation jobs in an effort to develop tight gas reserves. Bauxite fracs are increasing in the Rocky Mountains as operators search for deeper gas.

Well Servicing Market

While the exploding drilling rig count is well-publicized, the workover rig count is quietly following suit with a banner year. Nearly three-and-a-half new workover rigs enter the market place every day–just a half step faster than drilling rigs.

Well servicing expenditures will continue to increase, but much of the added cost will be due to inflation. The market should continue to expand as more and more wells are brought onstream. However, many forecasters predict 1981 as a peak year due to the decontrol of oil, making marginal wells once again profitable.

Data presented were based on PETROLEUM ENGINEER INTERNATIONAL's 1980 well servicing survey. Responses came from more than 150 independent and integrated companies. Appropriate base data used for projections were corroborated with data published by API and Petroleum Information Corp. ■

U.S. Gas Reserve Estimated At 913 Tcf

The latest evaluation of the remaining potential for natural gas production from conventional sources in the U.S. indicates that present proved reserves, plus the undiscovered potential supply, are most likely twice as large as the cumulative production since the beginning of the industry in the country.

The Potential Gas Committee, an independent group comprised of representatives of the natural gas industry, federal and state agencies, and academic institutions, said recently that exploration drilling and discoveries of the past 2 years have tended to confirm the general picture of the magnitude of the conventional natural gas resource base developed by the committee in its past reports. The latest estimates are based on the committee's biennial evaluation of the results of recent exploration and drilling activity for natural gas.

The estimates consider only those resources believed to be present in subsurface strata and susceptible to discovery and recovery by conventional methods and developing technology. The aggregate of the committee's estimates for various regions of the U.S. represents a resource potential of 913 tcf.

The committee says that more resources exist in the deeper parts (15,000 ft or deeper) of sedimentary basins than were previously estimated. This reflects the generally encouraging results of greater drilling to deeper depths in onshore basins together with the availability of more geophysical information, especially seismic surveys, of better quality.

There has been a definite increase in the number of wells drilled below 15,000 ft, according to PETROLEUM ENGINEER INTERNATIONAL's annual Deep Well Survey. In 1977, 476 wells were drilled below 15,000 ft in the entire U.S., including offshore. For 1980, PEI lists 859 wells drilled to depths below 15,000 ft.

A second trend emerging from the work of the Potential Gas Committee is that less resources are estimated to lie in offshore regions than had been thought previously. Reductions in offshore estimates reflect disappointing results from offshore exploration and drilling in the Baltimore Canyon and in the Gulf of Alaska, both areas where it was thought previously that there was considerable potential for natural gas.

Table 1. Total estimated potential supply of natural gas by depth increments, tcf

	Probable	Possible	Speculative
Onshore (drilling depth):			
Lower 48 states			
less than 15,000 ft	116	161	94
15,000 to 30,000 ft	35	103	102
	151	264	196
Alaska			
less than 15,000 ft	6	16	28
15,000 to 30,000 ft	—	—	—
	6	16	28
Total onshore	157	280	224
Offshore (water depth):			
Lower 48 states			
less than 200 m	32	43	35
200 to 1,000 m	2	22	23
	34	65	58
Alaska			
less than 200 m	2	13	68
200 to 1,000 m	—	—	12
	2	13	80
Total offshore	36	78	138
Total lower 48 states	185	329	254
Total Alaska	8	29	108
Total U.S.	193	358	362

The trend is reflected also in a reduction of estimates of the potential for the Gulf Coast offshore region. The committee feels this region has reached maturity in terms of both exploration and production, and there are now greater data available on which to base estimates. In addition, there have been transfers of potential resources to proved reserves and production.

The committee also has come to the conclusion that there probably are smaller resources of natural gas in Alaska than it had previously believed. This is based on the disappointing drilling in the Gulf of Alaska and a re-evaluation of onshore basins based on more geologic, geophysical, and drilling information.

The Potential Gas Committee's estimate of the potential supply of conventional natural gas in the U.S. as of the end of 1980 is given in Table 1. At the end of 1978, the committee estimated that the country's potential supply of natural gas was:

- Probable, 199 tcf.
- Possible, 399 tcf.
- Speculative, 421 tcf.

The total of these estimates is 1,019 tcf.

The U.S. Geological Survey's estimates of undiscovered recoverable resources (PEI, June 1980, p. 142) represent essentially the same quantities as are included in the Potential Gas Committee's possible and speculative categories.

The recent USGS estimates of the potential supply of natural gas are approximately 23% higher than those prepared in 1975. A large part of this increase, however, can be traced to an extension of the offshore area evaluated from a water depth of 200 meters in 1975 to a depth of 2,500 meters in 1980. There is a net increase of 13% in estimates for onshore areas, and a net increase of 56% in estimates for offshore areas. Comparisons of the USGS survey mean estimates of undiscovered recoverable resources and the Potential Gas Committee's estimates of possible and speculative resources are given in Table 2.

Significant Shifts

The new report of the Potential Gas Committee reflects significant shifts in the distribution pattern of estimated potential supply when compared with the report prepared for the end of 1978. For the lower 48 states onshore, 39%

of the potential is estimated to lie at depths between 15,000 and 30,000 ft, compared with 32% of the potential in 1978.

Despite a decrease in the total estimated potential for the U.S., estimates for deeper drilling also have been increased in terms of the actual estimated volume, from 199 tcf in 1978 to 240 tcf in 1980.

For the lower 48 states, 20% of the total potential is estimated to occur offshore, compared with 26% in 1978. This represents a decrease in the actual estimated volumes from 216 tcf in 1978 to 157 tcf in 1980.

Alaska now is estimated to contain 16% of the U.S. potential, compared with 19% in 1978. This reflects a decrease in the estimates of Alaskan potential from 189 tcf in 1978 to 145 tcf in 1980.

The Potential Gas Committee is considerably more optimistic than the U.S. Geological Survey about the potential for the eastern U.S., despite USGS's sharp increase in its 1980 estimate compared with 1975. In the offshore area of the Atlantic coast, the Potential Gas Committee estimate is less than that of the USGS, but most of this can probably be accounted for by the additional area included in the USGS estimate.

In the Gulf Coast region, the USGS has a larger estimate for potential onshore than does the Potential Gas Committee, but the reverse is true in the offshore Gulf area. Differences here apparently are due to different interpretations by the two groups.

In the Mid-Continent region, the committee's estimate is considerably lower than that of the USGS, which sharply reduced its estimate for the region. The committee, however, is of the opinion that there remains great potential for the region, particularly in the deeper portions of the Anadarko Basin. The committee also has a somewhat larger estimate for the potential of the offshore area of Alaska than does the USGS, and it is also more optimistic about the potential for the Pacific Coast area, both onshore and off. Estimates for other areas and regions of the U.S. appear to be essentially comparable.

The Potential Gas Committee estimates, which are somewhat more optimistic overall than the estimates of the U.S. Geological Survey, indicate that there still remain about 1,100 tcf of gas, including proved reserves, that can be produced from conventional reservoirs in the U.S. This is about twice the cumulative amount produced throughout the history of the industry to date.

Copies of the complete report, "Potential Supply of Natural Gas in the United States, as of Dec. 31, 1980," are available from the Potential Gas Agency, Colorado School of Mines, Golden, Colo. 80401.

Table 2. Comparison of estimates, conventional natural gas, tcf

	USGS		PGC*	
Year-end	1974	1979	1978	1980
	(mean) +		(most likely) +	
Lower 48 onshore	345	390	473	460
Lower 48 offshore	63	102	171	123
Alaska onshore	32	37	48	44
Alaska offshore	44	65	128	93
	484	594	820	720

*Potential Gas Committee estimates are the total of the Possible and Speculative estimates and are comparable to the USGS estimates of undiscovered recoverable resources.

+ USGS estimates represent the arithmetical mean derived by adding together maximum, minimum, and most likely estimates and dividing by three. Potential Gas Committee estimates are most likely estimates. These are most nearly comparable estimates from the work of both groups.

Calvin D. Saunders, vice president of research for Halliburton Services, is shown in front of the award-winning laboratory with a copy of the magazine in which the award was announced.

Halliburton Receives Lab Of Year Award

Halliburton Services' new $40 million research center at Duncan, Okla., has been named Laboratory of the Year by *Industrial Research & Development* magazine.

Headquarters for some 570 engineers, chemists, physicists, and electronics specialists, the 240,000-sq-ft center is designed for eventual expansion to 340,000 sq ft and 700 employees. In announcing its award, the magazine cited design objectives of the Halliburton center as including, "a setting suitable for quality research to provide for interaction and communication within and among the research groups, to provide a low-scale, campus-like atmosphere identifiable as one unified center, and to provide flexibility for expansion and modification through modular building components."

The Halliburton facility is not only the first laboratory in the U.S. Southwest to receive the 14-year-old award, it is the first petroleum industry facility to be so honored. In accepting the award, Halliburton spokesman said, "We are pleased beyond words to join such past winners as the Bell Telephone Laboratories, the Squibb Institute of Medical

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